1. Preface

In the post-soviet period the political relations and the former economic linkages of the South Caucasus countries, both between these and with the other CIS countries are altered. As a result, all the countries suffered. The economic collapse in Armenia had a more profound influence because of the Earthquake in Spitak in 1988, Karabakh conflict between Armenia and Azerbaijan, economic and transport blockade by Azerbaijan and Turkey. The economic collapse effected all the sectors, husbandry and industry included. There was a decrease of water consumption within these branches, in the industrial water supply, as well as in the irrigative system. Naturally, there was an increase in free transit streamflow to the neighboring countries parallel to the decrease of pollution of the transient rivers. It is clear, that in case of economic rehabilitation and growth, water consumption will increase, which will possibly lead to a complicated relationships with the neighbors concerning the consumption and protection of the hydrologic resources, if corresponding joint efforts are not taken. Activation of the economic inter-linkages between Armenia and the neighboring countries have not directly touched the utilization of the hydrologic resources, but it is anticipated. This activation particularly refers to energy supply and energy carriers. However, the exportation of electric power is stipulated by the existence of generating capacities.

It is also anticipated that in the matter of providing the region with potable water Armenia will play a dominating and donor role. As a background for this forecast may serve existence of spring and sweet abyssal waters, as well as mineral and thermal waters.

The hydrologic resources are the republics' significant property and their effective and multiform consumption will assist the country's socio-economic development. It needs to be mentioned, that isolated and complete consumption of the existing resources without making allowance of the neighboring countries' interests to the hydrologic system, is not advisable from the political and economical standpoints.

For the effective management of the hydrologic resources it is indispensable to be completely informed about the hydrologic resources of the neighboring countries, their consumption, existing problems and the possible interrelations in this sphere.

2. Nature of Armenia

The Republic of Armenia is situated in the South of Transcaucasus, on the Caucasus-Advanced Asia junction. Armenia borders Turkey and Iran in the West and south-east, and Georgia and Azerbaijan in the North and East. It occupies a territory of 29,74 thousand km2 having maximal extension of 360km. from the north-west to the south-east and 200km. from the East to the West. Armenia is a typical mountainous country: it occupies one of the hilliest parts of the Armenian upland. The highest point, i.e. the height of Aragats Mountain is 4090m, and the lowest point is 380m in the valley of the river Debed on the frontier with Georgia. The 90% of Armenian territory is higher from 1000m, 40% is higher from 2000m and the 16% is higher from 2500m (this area is non permanently populated). The average height of the country's territory is 1830m. There are 3 distinguished forms of relief in the orography of Armenia: volcanic uplands, folded and folded-clumpy ridges and intermontane hollows. The climatic conditions have distinguished diversity and major temperature contrasts. The soil nappe is variegated and has a vertical zoning. All these factors predetermine the exceptional variety of vegetation. Armenia is rich in mineral resources, metal and non-metal

mineral products. Except for the hydro-energy type, other energy resources don't exist. Combination of the multifarious natural conditions and resources preconditioned the multibranch complex development of the economy of Armenia.

3. Hydrologic system

Rivers and Lakes, as well as groundwater are hydrologic resources. The major part of the annually renewable surface and groundwater is congregated on the territory of Armenia. There are also transient waters: i.e. the river Araks and groundwater incoming from Turkey.

Surface and underground streamflow on the average of 7.5km3 annually is congregated at the expense of atmospheric precipitation and evaporation. River streamflow comprised of underground streamflow in a form of springs and surface streamflow makes 6.7km3. The input of the lake Sevan Basin is mainly expressed by its natural water flaw. Abyssal water constituents the remained part of the underground water flaw. The major part of this water flaw enters Ararat artesian basin. Water flaw congregation in Armenia has a territorial, height and time irregularity. The quarter of the territory of Armenia belongs to the drainage basin of the river Kur (Debed, Agstev rivers), the remained part belongs to the basin of the river Araks (Akhuryan, Kasakh, Mecamor, Razdan, Azat, Vedy, Arpa, Worotan, Gorisget, Wokhchi, Megry rivers and the Sevan Basin).

Streamflow of the river Debed (1,2km3) is a transit for Georgia, streamflow of the river Agstev and the river Kur (0, 64km3) is a transit for Azerbaijan. The part of influxes of the river Araks, Arpa, Worotan, Gorisget and Wokhchy (2,0km3) also enters Azerbaijan. The streamflow of the remained influxes of the river Araks, Akhuryan, Kasakh, Mecamor, Hrazdan, Azat, Vedi, and Megry is a transit for Azerbaijan and Iran.

Height distribution of streamflow formation for Armenia has a significant specificity. The lowland of the territory, where evaporation is more than atmospheric precipitations, there is no congregation of streamflow. It occupies a 5,4th.km2, i.e. 18% of the country's territory. There are internal-drainage areas also in Vayk (0,2th.km2), Megry (0,3th.km2), in the valleys of the rivers Debed and Worotan (0,15th.km2), in the Lake Sevan Basin (0,5th. km2) and etc.

Higher of the internal-drainage zone up to the height where evaporation in summer period is more than precipitations, streamflow formation is unstable. It occupies 13.85th.km2, i.e. the 47% of the country's territory. Only the highlands are zones of stabile streamflow formation. Internal-drainage zone has a negative aspect: it is considered as a desertification zone and requires environmental approaches.

The time irregularity of streamflow is mainly expressed both by years and by annual streamflow allocation. More than half (53%) of the annual streamflow passes in spring period. In some rivers, lacking regular run-off, the part of the spring streamflow reaches up to 75% (river Marmarik), and in the rivers having mainly spring nourishment it reaches up to 35%.

The country is comparably rich in sweat potable water. Spring and abyssal underground water refer to this type. Concentrated spring water mainly nourishing river streamflow makes 1,6mlrd.m3 annually. This figure also includes the mineral resources. The country is lacking hydraulic power. With this connection it is greatly surrendering such CIS countries as Georgia, Tajikistan and others. The existence of the hydrologic resources is predetermined by predominance of highlands, but conditioned by lack of water content the hydraulic power is not a great deal.

Total amount of potential theoretical resources is 21,8mlrd kilowatt-hours, from which the technically available ones don't exceed 7-8mlrd.kilowatt-hours and the economically beneficial ones less than that.

4. Consumption of Hydrologic Resources

Consumption of Hydrologic resources played a significant role in the country's economic development and in the social problems' solutions. Water is utilized for water supply of communal system, Industry, power engineering, husbandry and in the irrigative system. This one is the most water-retaining subsection. The irrigative agriculture in Armenia has a history of three thousand years.

In 1913 the irrigated area on the territory of the RA amounted to nearly 100th.hectare, and in 1920 it made a little over of 60th.hectare. The irrigation system development before and after the Second World War fetched the expansion of the irrigated area up to 320th.hectare in 1990. And on the contrary, the decline in the country's economy caused decay in the irrigative system as well. In 1998 the area of irrigated lands reached to the level of 188th.hectare. The amount of water supply of the irrigated areas is correspondingly reduced. The water scoop of 2,7mlrd.m3 decreased to 1,3mlrd.m3 and water consumption from 1,32 to 0,62mlrd.m3.

With an aim to overcome the space-time allocation of hydrologic resources, for reallocation of streamflow and provision with irrigation numerous irrigative systems with channels are built the full length of which is exceeding 20th km. It includes backbone channels of up to 100km. 32 irrigative reservoirs and 47 artificial pools are also currently in use. The largest of the reservoirs is Akhuryan (525mln.m3) built on the river Akhuryan. The total dimension of these reservoirs is 1.11mlrd.m3. They occupy a territory of 100th hectare. There are also reservoirs currently under construction and in a stage of project with a dimension of 0,94mlrd.m3. 365 small and big pumping plants with a capacity of 440 megawatt are established for irrigation of lots, situated higher than the irrigation heads. They occupy 130th hectare land. In connection with the energetic crisis and high prices on energy, many pumping plants don't operate. There is an intention of provision a part of these lands with gravity irrigation, requiring huge investment for construction of new canals.

Water supply for industrial purposes has been reduced from 0,52mlrd.m3 in 1985 to 0,12mlrd.m3 in 1998. Water consumption for communal needs has also been reduced from 0,62mlrd.m3 in 1985 to 0,22mlrd.m3 in 1998. There are major losses (up to 55%) in the net of urban water supply. Calculations, made by the leading specialists of this sphere, show, that the necessary level of increase of sweat water volumes by the year 2020 will reach to 340mln.m3 in annum. Water consumption intended for heat-removing in the heat-and-power engineering is 50mln.m3.

Hydroenergetics had a considerable improvement in Armenia. By 1962, after completion the Sevan-Hrazdan cascade with an installed capacity of 556megawatt and output of 2,5mlrd. kilowatt-hour, it provided with 95% of demands in electric power. Currently in the conditions of extinction of energy drawdown from the Lake Sevan, this cascade works with an irrigative regime and its output amounts to 570mln. kilowatt-hour. There are numerous hydropowerstations the biggest of which is Vorotan with an installed capacity of 404megawatt and output of 1,1mlrd.kilowatt-hour, small ones with an output volume of 120mln.kilowatt-hour annually. There is an intention to build 325 small hydropowerstations with an installed capacity of 274megawatt and output volume of 830mln.kilowatt-hour annually. These stations utilize energy of waterfall. For a purpose of water regulation water reservoirs have been built, the biggest of which is

Spandaryan reservoir on the river Vorotan with a volume of 257mln.m3. Both, Spandaryan and Tolorsky water reservoirs have mainly energy-irrigative function.

5. Hydrologic Problems of Armenia and Steps Towards Hydrologic System Management.

In Armenia, as in the other countries, management of the hydrologic system includes problems of water supply of the national economy and protection of the hydrologic system regarding disturbance of its natural state. Problems of water supply mainly exist because of mismatch between supply and demand. It is explained by geographical and time irregularity of water storage distribution on one hand, and irregularity of distribution of water consumption on the other hand. In addition, water consumption and irregularity of water distribution often have straight inverse character, i.e. consumption volume is huge where amount of hydro resources is small and doesn't match with the environment of naturally amended resources, river run-off. Such a mismatch refers first of all to the most water-retaining consumer, land irrigation. The irrigated lands are situated in comparatively dry districts where drain is usually not formed. It generates a necessity of water transfer from a high-water territory to law-water one, or construction of main-line trackages. Thus, the central region of Armenia, including the basins of rivers Kasakh, Mecamor, Hrazdan, Azat, Vedy and Lake Sevan being a big territory is comparatively rich in resources (more than half of water demand is concentrated on this territory). With this regard there should be a water transfer from the south-east region via Lake Sevan.

In the Western region, i.e. Shirak, including basin of the river Akhuryan, the hydroeconomic balance is also stressed. In the forthcoming future here will be a need of water transfer from the neighboring regions, say from the north-east part of Armenia.

Another mismatch of supply and demand becomes apparent in irregularity of annual distribution. Thus, if summer river run-off amounts to 19% annual value, consumption ends up to 66% of its annual value (from the standpoint of perspective development). Comparison of summer minimal monthly drain (4?6% annual value) with maximal monthly consumption (26-30%) will lead to a more contrast. The main possibility to avoid this difference is regulation of the river run-off in water reservoirs, i.e. transfer of winter-spring and free of use water to summer. Dischargeable capacity of the existing water storages (1,0 mlrd.m3) makes 15% of annual average river run-off. This volume pretends to be doubled. Contrast of streamflow distribution and irrigation demand is still worked out by selection of high rated provision of rivers with an irrigation purpose, what decreases the volume of usable resources.

There are numerous problems in Armenia concerning protection of hydrological system regarding disturbance of their natural state, i.e. water withdrawal from the sources (rivers, lakes) and reversion of return water and wastewater. There are elaborated programs for protection of hydrologic system from pollution through establishment of purifying stations and elimination of the ill effect of hydroeconomic construction on the water bodies.

Special efforts will be applied for reduction of water losses in the nets of water supply and irrigation. The objective of management is to eliminate leakages in conservation of resources and increase the efficiency of their consumption. Proposition of the valley Ararat is partially concerning the ill effect of leakages from the irrigative network and low efficiency of irrigation. Here, in conditions of absence of natural damping and presence of irrigation water demands there are waterlogged grounds and areas with high level of underground waters. Here is a complex problem of land reclamation to face.

The matter of Lake Sevan has a national significance. It particularly concerns the intensive decrease of its level diminution of depth and volume brought to alterations of hydrophysical characteristics and thermobiological environment of the Lake Sevan.

Parallel to population growth and entrepreneurial activity in the Lake Sevan Basin without observance of water protective norms and restrictions bring about pollution of the Lake Sevan with industrial and communal sewage waters, return waters from the fertilized agricultural sewage farms, as well as enrichment of Sevan with biogenic elements and toxic substances. Degradation of water quality and alterations in the ecological balance of Lake Sevan and its Basin is mainly conditioned by these two factors.

Thus, solution of this problem has three aspects and corresponding measures to take: water-management, water- protective and ecological.

Water-management functions include augmenter of hydro resources of the Lake Sevan in addition to its natural resources with an aim to ensure positive water balance, as well as rise of water level to an optimal volume, stipulated by enhancement of water quality, thermobiological environment and recovery of the ecological state of the Lake. Part of these steps are already taken, currently the channel Arpa-Sevan is operating, and it is only a matter of time to complete the construction of the channel Worotan-Arpa for transferring the part of streamflow of the river Worotan into the Lake Sevan through the channel Arpa-Sevan. It is also projected to finish construction of Egward water reservoir having an aim to reduce the irrigation drawdowns.

Water protective measures intend to ensure cleanliness of water and streamflow incoming into the Lake Sevan, maintain the sanitary code on the shoreline.

These measures will assist to improve the ecological state of the Lake and its Basin in addition to the steps taken towards rehabilitation of living conditions of Flora and Fauna of the Lake Sevan.

Important problems of management of available hydro resources remain reduction of ill effect and soil erosion.

6. Cooperation with the neighboring countries regarding utilization and protection of hydro resources.

The common water interests that can grow along with the aggravation of the problem of the total lack of water, encompass the issues of water utilization in the utilities, agricultural and industrial water supplies, irrigation, use of hydro-energy resources and water environment for fish breeding, recreation and water sport, water immaculateness and protection of water resources from the quantitative and qualitative exhaustion, as well as protection of water objects and the landscape from the harmful effect of water, etc.

These interests, taken both separately and in complex, are expressed in the relations with a particular neighboring country in their concrete forms.

Water Utilization for Irrigation:

The water of the rivers Arax and Akhurian is used by Armenia and Turkey on parity basis. The regulated flow, formed in the territory of the republic and Turkey, is used in this country for the irrigation of 30 thousand ha of land. The same amount of hectares of land is irrigated by Armavir irrigation system, constructed in 1930s'. Water flows into

this system from the River Arax below the junction of the River Akhuryan with Arax. The right to use the half of the water flow of Arax allows to double the head-gates and increase the irrigation area. Its technical capacity is available at present and what remains to be done is to expand the irrigation net.

The flow of the River Debed is used for the irrigation of land areas in the territory of Georgia. The head-gates is built on the river on the border of the republic below the calibration point of the Noyemberian pump irrigation stations. During the operation of these stations (prior to the increase of the energy tariffs and their stoppage), in the dry years and summer time water was not sufficient for the both head-gates. In future the same situation may occur in the event of restarting irrigation of Noyemberian land. For the unhindered development of irrigation in the territory of the republic, as well as satisfaction of the needs of Georgia in irrigation, water regulation of the river flow is necessary. It is feasible to achieve this goal by constructing the Armanis reservoir through joint efforts and providing water releases from it. This can be implemented in the basin of the River Dzoraget, a tributary of Debed, near the town Stepanavan. This reservoir will be part of the energy-irrigation complex for the utilization of the River Debed water.

The water of the River Aghstev and its tributary Voskepar is used for irrigation purposes in the republic and in the territory of Azerbaijan after it is regulated in the reservoir. The water relations between these two countries along with the consideration of the irrigation regime and water amount regulation in the reservoirs, one of which is in the territory of Azerbaijan (r. Aghstev) and the other is in the territory of Aremnia (r. Voskepar), need to be adjusted. The situation is the same on the minor tributaries of r. Kur, Akhum, Tavush, Khndzorut (Akhunja).

In the south-east of Armenia the rivers Arpa, Vorotan, Gorisget and Vokhchi flow into the territory of Azerbaijan. Their water is used both in Armenia and Azerbaijan. During the Soviet power there was an agreement on parity utilization of the Arpa water by the two parties. No agreement has been concluded on the utilization of the water of the other above-stated rivers. It will be necessary to address this issue after the settlement of the Kharabakh conflict.

The issue of water utilization regarding each of the rivers has its peculiarities and should be solved according to these specifics. It should be taken into account the fact that these rivers originate in the territory of the republic.

The River Arax is separating Armenia from Iran in the 40km section in the south of the republic. Currently the Armenian Project is in preparation, aiming at directing the flow of this river and using it for irrigation purposes in the region of the Persian Gulf.

Utilization of Drinking Quality Water:

The relatively major resources of sub-terrestrial water and springs allow to export drinking water once certain technical work is accomplished. In this case the expenses on water transportation are not calculated. The initiative will aim at providing the irrigation system with water versus the sub-terrestrial and spring waters in places where the latter are used. This may be feasible also through the elimination of water losses in the irrigation net, the increase of the efficiency ratio and introduction of the advanced water saving technologies in the irrigation net. The extraction of the sub-terrestrial water from the depths and the interception of the sub-terrestrial under-lava streams in the foothills require definite investment and certain difficulties need to be overcome.

In some of the regions of the republic the balance of the drinking water includes spring water that is not used there. There is an intention to export spring water from the Siunik Marz to the region of the Persian Gulf where there is high deficit of drinking water.

There is a perspective to create a centralized reserve of water supply for the whole Transcaucusus region. The Lake Sevan will be used for that purpose. This can be implemented in case the Sevan problem is solved completely, the quality of its water is improved and its level grows by 6 meters, thus, allowing to create a reserve pool.

Utilization of hydro-energy resources:

The increase of the Lake Sevan level and the annual replenishment of its water resources will allow to create a big regulating pool in the lake which can be used for the generation of the high-quality electric energy in the winter season, needed by the neighboring republics. Presently electric energy is exported to Georgia mainly in winter. The construction of the hydro-power cascade on the River Debed will facilitate the export of energy. The water irrigation-energy complex to be built on this river has been designed. The said complex will make it possible to generate electric energy mainly in the winter time along with the rehabilitation of the irrigation system for the Noyemberian region (instead of the paralyzed mechanical irrigation) and to release water for irrigation purposes to Georgia. For the creation of the complex major investments and joint actions are needed.

Hydro-power plants for joint utilization can be constructed on the border rivers and on the basis of the water reservoirs, built on them. Preliminary projects on the generation of energy from the water of the River Arax in the bordering section with Iran, the section past the junction with Akhurian, bordering Turkey, as well as on the River Akhurian (Akhurian reservoir), etc, have been developed.

Maintenance of water resources and water objects in border sections:

During the period of the Soveit power, when the mining and chemical industries had rapidly developed, the problem of pollution of the River Vokhchi in the south-east and the River Debed in the north of the republic was crucial. At present the isue of pollution of these rivers is not the subject of concern of Azerbaijan and Georgia. However, in the nearest future, when the Kajaran copper-molybdenum plant is revived again the problem of pollution of the Vokhchi with the industrial waste will arise. The River Debed is under the threat of being polluted in the event the Alaverdi Copper-Chemical Plant and the Vanadzor Chemical Plant are re-launched. For the protection of the Debed water from pollution introduction of waste recycling and expensive waste-free technology is necessary. Similar problems, although less serious, exist in regard with other rivers as well.

The waterside land of the River Arax is flooded in spring in the section, bordering Turkey, the bank-protective constructions and barriers are ruined, and the demarcation line is changed. The protection of the riverbanks and adjustment of the river course require major labor force every year. The construction of the water reservoir on this river will allow address the problem of bank protection along with the other ones (irrigation and energy).

The protection of the terminal rivers and their bordering sections must be the subject of concern of both countries on the opposite sides of the rivers.

Utilization of Water Objects for Tourism, Recreation and Water Sports:

Armenia has resources for water recreation and sports and international tourism, in particular, the Lake Sevan and its waterside zone. The water reservoirs can also be adapted to serve these purposes. For such utilization of water objects, especially reservoirs, the water level regime should be adjusted and complex water protection requirements to the water object should be set forth.

7. Concepts of Hydro Resources Integrated Management

For the regional-integrated management of water resources three sets of issues on the national level should be solved.

1. Study and assessment of resources

2. Regulation of legal and administrative forms of management

3. Preparation of projects on cooperation.

The first set of issues includes the study, investigation, identification of the specifics of water, hydro-energy resources and their utilization and the technical ways of resource management. It also covers the issues of expansion of hydro-meteorological, water and water protection ecological monitoring. The study should end in assessment of resources, which in its turn, will establish the basis for wide range activity in regard with water utilization and nature protection. This assessment must be considered a priority in planning the national economy.

The second set of issues includes regulation and precision of the legal, structural, functional and administrative forms of water resources management in compliance with the national development program considering water resources state property. This forms of management shall allow to develop and implement the state technical and economic policy and strategy on utilization and protection of water resources and water objects. To regulate water relations at the state level, to distribute water resources among the marzes and water consuming sectors, to provide state support and control in regard with the study and assessment of water resources, preparation of long term plans and complex projects, state management of the major water objects, water systems and reservoirs, to elaborate an effective legislative and legal system, as well as system of payments and other norms for water utilization providing stable development of the ware activity, to work out interstate initiatives aimed at the utilization and protection of border water resources and objects.

It is evident that a relevant scientific-technical center is necessary for the preparation and implementation of the international technical assistance projects. Apart from developing projects, the goals of the center will cover also participation in water relations in the regional organization for economic integration of the South-Caucasian region, which is likely to be established in the future.

Agreements on cooperative water resources utilization between the neighboring countries shall be concluded under the United Nations Convention ‘On the Rights of Non-navigational Utilization of International Water Streams’(1997), as well as according to the principles and recommendations of the conferences under the auspices of the United Nations Organization on environment and development.

The problem of water resources regional-integrated management must be solved as an issue included in the ‘agenda of the 21st century’, announced by UNO as one on cooperation and partnership in regard with the preservation and rational utilization of resources for development purposes.